

Aging and Suppression: Memory for Previously Relevant Information

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In the 1st part of the experiment, older and younger adults read a series of high-cloze sentence frames, each missing its final word (e.g., "She ladled the soup into her _____"). Subjects were instructed to predict the ending for each. For critical sentences, the predicted final word (*bowl*) was not shown. Instead, an unexpected but acceptable ending (*lap*) was provided as the target. On a subsequent indirect memory test in which subjects generated endings to medium-cloze sentences, older adults showed reliable retention of both the disconfirmed (*bowl*) and target (*lap*) endings. Younger adults showed retention of only the targets. Results are consistent with the Hasher and Zacks (1988) view that the impaired inhibitory mechanisms of older adults impede the abandonment of no-longer-relevant thoughts.

Although age-related declines in memory are well documented (Burke & Light, 1981; Craik, 1977), definitive identification of the cognitive processes responsible for these changes has not yet been achieved. One prominent theory has argued that an age-related reduction in attentional capacity contributes to decrements in both the encoding and later retrieval of stimulus material. Such a reduction would place constraints on the processing of incoming information. As a result, there would be a diminished amount of effortful processing (Hasher & Zacks, 1979), which in turn would produce failures in memory (Craik & Simon, 1980; Guttentag, 1985; Hasher & Zacks, 1979; Rabinowitz, Craik, & Ackerman, 1982; Salthouse, 1982). In spite of the intuitive appeal of the attentional capacity perspective, however, there is little direct evidence linking attentional capacity to memory performance, and the theory has been extensively criticized (e.g., Allport, 1987; Light, 1988; Navon, 1984; Salthouse, 1982).

A recent theory suggests an alternative explanation of the reduced memory performance of older adults (Hasher & Zacks, 1988). In particular, that theory proposes that age-associated changes occur in the functioning of working memory (Baddeley, 1986), particularly in those largely inhibitory attentional processes that control access and temporary maintenance of task-irrelevant information. This theory suggests that the decreased efficiency of inhibitory mechanisms with aging affects

the contents of working memory and, subsequently, the retention of information as well.

Evidence of the operation of attentional inhibitory mechanisms can be seen in a variety of selection tasks in which subjects must respond to one item in an array (by naming it, for example). If the current target (whether letter, word, or object) has just served as a distractor, naming of that target is slowed relative to a control condition in which the new target has not just served as a distractor. The inference is that—at least under some circumstances—selection of a target entails suppression of distractors. Several recent studies reported such an effect for young adults but failed to find evidence of suppression with older adults (Hasher, Stoltzfus, Zacks, & Rypma, 1991; McDowd & Oseas, 1990; Tipper, 1991). Apparently, inhibitory mechanisms involved in selection of targets and avoidance of distractors are less efficient for older adults.

There is also some preliminary evidence of older adults' failure to suppress nontargets in a reading comprehension task. In a recent study (Hamm & Hasher, 1990), subjects were tested for their endorsement of inferences that were either compatible or incompatible with the meaning of a series of prose passages. The incompatible inferences were ones that all subjects might have thought about near the beginning of each text, but which were clearly disconfirmed later by additional information. The results indicated that older adults were less likely than younger ones to discard the previously relevant, disconfirmed information, although they were equally able to arrive at the correct inferences. This suggests an increased tendency with aging to maintain, rather than inhibit, nontarget information in working memory.

In the present experiment, our goal was to further examine age differences in inhibitory processing by assessing memory for task-relevant target words as well as for words that were evoked in the context of a study task but that quickly and clearly became irrelevant to that task. To do this, we needed to get subjects to think about words that were potential targets, but that—in the end—were not actually memory targets. We did this by means of a task in which subjects generated the final word for each of a series of high-cloze sentences. Half the time,

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their generations were confirmed by presentation of the highly probable ending. For the critical sentences, however, the obvious, high-cloze ending was disconfirmed by the presentation of a plausible but unexpected ending (e.g., the word *lap* instead of *bowl* for the sentence frame "She ladled the soup into her _____"). Subjects were fully informed that it was only the ending that was actually presented that was to be remembered. Our expectation was that older but not younger adults would show retention of their generated but disconfirmed final words. If older adults have greater difficulty suppressing irrelevant thoughts once they are generated, they should remember those items, even though they are no longer relevant to the task.

In this experiment, memory for target and disconfirmed information was tested by means of an indirect memory test (i.e., one in which memory is expressed through performance on a task that does not make explicit reference to or require conscious recollection of the previously studied stimuli [Johnson & Hasher, 1987; Richardson-Klavehn & Bjork, 1988]). On this test, subjects were asked to provide one-word endings for a series of medium-cloze sentence frames (e.g., "Scotty licked the bottom of the _____" and "The kitten slept peacefully on her owner's _____"). The dependent measure was the magnitude of repetition priming, or the increase in frequency above baseline with which subjects completed critical sentences with previously generated (e.g., *bowl*) and presented words (e.g., *lap*).

An indirect test of memory was selected for a number of reasons, the most important of which is that such tests do not require direct retrieval of information from the prior study episode. They also do not require discrimination between new and old or relevant and irrelevant material. Thus, indirect memory performance can provide a window into the contents of memory by measuring the relative availability of target and nontarget information independently of their accessibility. Stimuli that have been the focus of attentional processing would be expected to show indirect memory, whereas stimuli that were actively suppressed should show little.

Previous research has shown that older and younger subjects generally show equivalent or nearly equivalent repetition priming (Chiarello & Hoyer, 1988; Howard, 1988; Light & Singh, 1987). Although these earlier studies did not involve the simultaneous presentation of task-relevant and irrelevant stimuli, one might nevertheless predict similar findings in the present experiment. Therefore, if older adults fail to suppress previously relevant but disconfirmed information, then age differences should emerge in the relative amount of priming for targets and disconfirmed words, although the total amount of priming may be equivalent for young and old. On the other hand, if repetition priming for targets shows no age differences, and older adults attend to both target and disconfirmed words, then the total amount of repetition priming may actually be greater for the older age group.

A final component of the present experiment involved the administration of a brief battery of standardized neuropsychological tests. This included the Wechsler Adult Intelligence Scale—Revised (WAIS-R) Vocabulary subscale (Wechsler, 1981), the Controlled Word Association Test (CWAT; Benton & Hamsher, 1976), the Stroop Color-Word Interference Test (Stroop, 1935), and the Rey Auditory Verbal Learning Test (RAVLT; Rey, 1964). Vocabulary test scores provided a rela-

tively age-insensitive estimate of subjects' verbal abilities. The other tests are known to be sensitive to age-related changes in cognitive processing (Comalli, Wapner, & Werner, 1962; Lezak, 1983) and were hypothesized to tap some of the cognitive processes involved in the experimental task (e.g., interference [Stroop test], memory [RAVLT], and word retrieval [CWAT]). Scores on these tests were predicted to correlate with the repetition priming effects, particularly with the expected age differences in priming of target and disconfirmed words.

Method

Subjects

Subjects included 44 younger adults (38 women and 6 men) and 24 healthy older adults (14 women and 10 men). The young adults were all undergraduate students participating as part of a requirement for an introductory psychology course. They had a mean age of 20.1 years (range: 17–28, $SD = 2.3$) and had completed a mean of 13.8 years of education. The older adults were recruited through notices and advertisements in local newspapers. All were native English speakers with vision that was normal or corrected-to-normal. They all reported themselves to be in good health. None had histories of significant neurologic or psychiatric illness or were currently taking psychoactive medication. They had a mean age of 66.5 years (range: 60–76, $SD = 5.5$) and had completed an average of 15.7 years of education. The older adults had significantly more education than the younger adults, $t(66) = 4.5$, $p < .0001$.

More younger than older subjects were tested because a significant proportion of the younger adults became aware of the relationship between the stimuli presented for study and those tested on the indirect memory test. Additional young subjects were included so that differences in performance associated with this knowledge could be assessed.

Materials and Apparatus

Twenty-eight sentence contexts with highly predictable endings served as the experimental study sentences (e.g., "She ladled the soup into her bowl"). For each sentence, a low-probability ending was also constructed (e.g., *lap*, for the example given). Each low-probability ending created an unlikely but meaningful sentence. Some of the experimental sentences were taken from the Bloom and Fischler (1980) norms, whereas others were constructed specifically for this study. The likely and unlikely endings were similar in frequency of occurrence, according to Kucera and Francis (1967) norms (116 vs. 109 occurrences per million, respectively). An additional 14 sentence contexts with highly predictable endings were taken from the Bloom and Fischler (1980) norms and were used as fillers. Tables 1 and 2 give examples of the stimuli. Two practice sentences were also constructed.

The experimental study sentences were divided into two subsets of 14 sentences each, in which final words had equivalent frequencies of occurrence in the English language. Each subset was used equally often with each age group. All subjects also received the 14 high-cloze filler sentences. Thus, half of the sentences seen by each subject had highly predictable endings. The fillers were intermixed with the study sentences, with the constraints that 2 fillers appeared at the beginning of the series, 2 at the end, and no more than 3 of the experimental sentences appeared consecutively. In addition, two orders of presentation were constructed, and each order was used for half of the subjects in each age group.

The stimuli for the indirect memory test consisted of sentences in which final words were moderately predictable from the sentence frames (expected cloze value was approximately .50). For each of the 28

Table 1
Examples of Study Stimuli

Sentence type	Expected ending	Target ending
Experimental		
She ladled the soup into her	bowl ^a	lap
The gorilla was angry and beat its hairy	chest ^a	stomach
Filler		
The rude waiter was not given a	tip ^b	tip
His boss refused to give him a	raise ^b	raise

^a Expected endings for experimental endings were disconfirmed by the provision of an unexpected target. ^b These endings were not disconfirmed. Memory for the endings of the filler sentences were not tested.

experimental study sentences, a pair of test sentences was constructed, for a total of 56 (see Table 1 for examples). One sentence in each pair had as its most probable ending the highly predictable but disconfirmed ending of the corresponding study sentence. The other had as its most probable ending the unlikely actual presented ending. For example, the sentences, "Scotty licked the bottom of the *bowl*," and "The kitten slept peacefully on her owner's *lap*," form a set with the study sentence, "She ladled the soup into her bowl/lap."

All 56 test sentence frames were presented to every subject. For any given subject, 28 of these matched the studied sentences. These included 14 tests of target endings and 14 tests of disconfirmed endings. The other 28 test sentence frames matched the 14 study sentences that had not been studied and so made up the baseline control condition for that subject. Two different orders of presentation were constructed for the test sentence frames, and each order was used for half the subjects.

The neuropsychological test battery included the Stroop test, the RAVLT, the CWAT, and the Vocabulary subscale of the WAIS-R. The Stroop test is a timed test composed of three parts, each with 50 items. In the first subtest, subjects name the colors of small, colored rectangles; in the second, subjects read color words printed in black ink; and in the third, subjects must name the color of ink in which a conflicting color word is printed. Performance on this final part is generally slowed, presumably because of response interference between the name of the target color and the color word name. The RAVLT is a direct memory test that consists of a 15-word list that is read aloud to the subject five times, with free recall tested after each trial. On the sixth trial, a new list is presented once for recall, after which free recall for the first list is again assessed. The CWAT is a speeded word-retrieval test, in which subjects must generate, in 1 min, as many words as possible beginning with a designated letter. This is repeated three times with the letters *F*, *A*, and *S*.

Table 2
Examples of Test Stimuli

Condition	"Correct" ending
Disconfirmed	
Scotty licked the bottom of the _____.	bowl
The senator was startled by the sudden pain in his _____.	chest
Target	
The kitten slept peacefully on her owner's _____.	lap
The fattest part of Bob is his _____.	stomach

Procedure

Subjects were seated in a moderately lit room at a distance of approximately 54 cm from the monitor of a Zenith microcomputer. The study sentences were presented one at a time, centered on the screen, with large letters that ranged from 0.6 to 1.0 cm high, depending on the letter of the alphabet. At the beginning of each trial, a warning signal (+) appeared on the screen for 750 ms. Then the sentence frame minus its final word was presented all at once. The presentation duration of sentence frames was determined by the number of words in the frame, with each word being accorded 275 ms. After a further pause of 400 ms, the final word appeared. For the filler sentences, this was the highly predictable ending. For the experimental sentences, this was always the unlikely ending. Once the ending appeared on the screen, the entire sentence remained visible for 2,000 ms before the screen was cleared.

In the study procedure, subjects were told to read each sentence silently as it appeared on the screen and to try to remember the last word for a later memory test. In addition, they were told that there would be a pause before the last word appeared on the screen and that during that pause they should try to think what the ending would be. As a rationale for this instruction, they were told that being active and generating the words on their own would help them to remember the words later. They were also warned, however, that in some cases the sentences would end differently than what they expected, and they should try to learn only the endings that were actually presented. After these instructions, the subjects were given two practice sentences.

After the study sentences were presented, subjects were told that several unrelated tests would be given before the memory test. A delay interval of approximately 5 min was introduced, during which the Stroop test was administered. Then the critical sentence completion task was given. Subjects were not told that the sentence-completion task was a memory test and, in fact, were led to believe that they were helping the experimenters develop stimuli for a future experiment. They were told to simply read each of the incomplete sentences aloud, completing it sensibly with the first word that came to mind. One sentence frame appeared on the computer monitor at a time and remained in view until the subjects supplied an ending aloud. The experimenter recorded the subjects' responses. The subjects then pressed the space bar on the computer keyboard to advance to the next sentence. This part of the experiment was self-paced.

After completing this test, participants were questioned about their awareness of the relationship between the study and test procedures. The interview began with two general questions: "What do you think is the purpose of the study so far?" and "When you were doing the sentence completions, did you think there was anything unusual about the sentences?" Further questions were more leading and asked explic-

itly whether the subjects noticed any connection between the two tasks and, if so, what they noticed and when. If subjects reported awareness of a relationship between the two tasks, they were asked specifically about conscious attempts to use (or avoid using) the sentence endings from the study task as endings in the sentence-completion task.

After this interview, a free-recall test was given, followed by the RAVLT, the CWAT, and the Vocabulary test. On the recall test, subjects were asked first to write down all the target endings they could remember from the study sentences. Then they were asked to recall the endings they had expected to see, but which were not actually presented (e.g., the disconfirmed words). Overall, there were low levels of recall of target and disconfirmed words for both young and older subjects (a total of 4.7 and 1.7 words for the two age groups, respectively). Because of these floor effects and the possibility of differential effects of the intervening sentence-completion test on the two age groups, no further analyses of these data are reported.

Results

Using responses to the interview, subjects were categorized as being either aware or unaware of the relationship between the study and test procedures. In general, aware subjects realized—often after responding—that some of their responses were words from the first part of the study. However, 4 younger adults reported consciously using or avoiding using the studied words as endings in the indirect memory test, and these subjects were replaced. Of the 44 younger adults who were included in the study, 24 (54%) reported awareness of the relationship between the study and test procedures. Of the 24 older adults, only 3 (13%) reported awareness. One older adult was replaced because she had not followed the instructions.

For each subject, the proportion of sentence completions that matched the experimental words was calculated for each of three conditions. The target condition comprised words that matched the unlikely actual presented endings of the critical study sentences (e.g., *lap*). The disconfirmed condition consisted of words that matched the likely endings that were thought about but not presented (e.g., *bowl*). The control condition consisted of words that matched the target and disconfirmed endings from the subset of sentences that was not presented to a particular subject for study. From these three scores, two repetition priming scores were calculated by subtracting the control condition score from the target score and from the disconfirmed score, respectively. Table 3 shows the means for the three conditions and their corresponding repetition priming scores.

The first step in the analysis was to compare the completion rates of younger and older adults for the control sentences. A *t*

test failed to detect reliable age differences ($p > .10$), and further analysis of age differences was conducted using the repetition priming scores for the target and disconfirmed conditions.

A two-way repeated measures analysis of variance (ANOVA) was conducted with age (young vs. old) as a between-subjects variable and condition (target vs. disconfirmed) as a within-subjects variable. The results of this analysis indicated no significant overall age differences in the total amount of repetition priming ($F < 1$), a finding in agreement with that reported elsewhere in the cognitive aging literature, although with different indirect memory tasks (e.g., Light & Singh, 1987). In addition, there was greater repetition priming for target than disconfirmed words (10.03% vs. 2.78%), $F(1, 66) = 7.67$, $MS_e = 127.09$, $p < .007$, $\omega^2 = .08$, an effect whose interpretation is modified by an interaction between age and condition, $F(1, 66) = 7.67$, $MS_e = 127.09$, $p < .007$, $\omega^2 = .08$.

To examine further the nature of this interaction, analyses were conducted separately for each age group. A one-way ANOVA for young subjects alone showed significantly greater repetition priming for the target than for the disconfirmed words, $F(1, 43) = 23.89$, $MS_e = 115.56$, $p < .0001$, $\omega^2 = .34$. Priming for the targets, but not the disconfirmed items, was reliably greater than zero, $t(43) = 5.05$, $p < .0001$ and $p > .10$, respectively. In contrast, older adults showed priming that was equivalent for target and disconfirmed words ($F < 1$). *T* tests carried out to determine whether each of these effects was significantly greater than zero for older adults approached significance: target words, $t(23) = 1.86$, $p < .08$; disconfirmed words, $t(23) = 1.99$, $p < .06$. Thus, older adults showed equivalent memory for the target and disconfirmed sentence endings, whereas younger adults showed memory only for the presented target endings. Younger adults did not show priming for disconfirmed endings, that is, words that were thought about, but not actually presented.

Standardized Tests

Table 4 shows the mean scores and standard deviations for each of the standardized tests administered. We carried out *t* tests to compare younger and older adults on each test. Older adults scored significantly higher than young adults on the WAIS-R Vocabulary subscale, $t(66) = 7.71$, $p < .05$, and the CWAT, $t(66) = 3.19$, $p < .05$. The finding of better vocabulary is not unusual in studies of aging and indicates the overall high level of verbal ability in this sample of older adults. On the other hand, verbal fluency, as measured by the CWAT, is known to

Table 3
Proportions of Experimental Words Generated as Sentence Completions

Subject group	Condition			Priming effect	
	Target	Disconfirmed	Control	Target	Disconfirmed
Young	62.2	51.0	49.9	12.3	1.1
Old	53.0	53.0	47.0	6.0	6.0
Mean	58.9	51.7	48.9	10.0	2.8

Note. For the young subject group, $n = 44$; for the old subject group, $n = 24$.

decrease with normal aging (Lezak, 1983) and in the early stages of dementia (Martin & Fedio, 1983). Nevertheless, this test is also sensitive to subjects' level of education (Lezak, 1983), and in this set of data, performance on the CWAT was significantly correlated with educational attainment for the older adults ($r = .41, p < .05$). Thus, the higher scores in this sample of older subjects give further evidence of their excellent verbal skills. (In fact, for the older but not the younger group, vocabulary and CWAT scores showed a moderate positive correlation, $r = .42, p < .05$, as if a good knowledge of words may offset the expected age-related decline of speeded word retrieval.)

Younger adults performed better than older adults on the other two standardized tests administered: the Stroop test and the RAVLT, measures of susceptibility to response interference and direct memory, respectively. On the Stroop test, older and younger adults showed equivalent response times on the first 2 portions, in which they named colors and read color words. However, older subjects were 28 s slower on the color-word portion, in which they were required to name the color of ink of a conflicting color word, $t(66) = 4.1, p < .0001$. There was also a tendency for older adults to make fewer errors on two of the three parts of the test, $t(66) = 2.16, p < .05$, and $t(66) = 1.92, p < .06$, for the word naming and interference parts, respectively, suggesting a greater emphasis on accuracy in the older adults and a possible small age difference in the trade-off between speed and accuracy.

On the RAVLT, a two-way repeated measures ANOVA was carried out using the scores from the first 5 learning trials.

Table 4
Standardized Neuropsychological Tests

Test	Young		Old	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Controlled Word Association Test**	40.1	9.0	49.7	15.8
WAIS-R Vocabulary**	51.0	7.8	64.3	4.3
Stroop test				
Color				
Time in seconds	56.0	12.2	60.9	11.2
Total errors	1.4	1.4	1.5	1.7
Word				
Time in seconds	39.9	5.0	40.4	6.8
Total errors*	.6	.7	.3	.5
Color-word				
Time in seconds**	99.3	19.6	127.5	37.4
Total errors	3.1	2.7	1.9	1.9
Rey Auditory Verbal Learning Test				
List A***				
Trial 1	7.8	1.7	7.1	2.0
Trial 2	10.5	2.3	9.1	2.0
Trial 3	12.2	1.8	10.8	2.1
Trial 4	12.9	1.9	11.9	1.9
Trial 5	13.9	1.5	12.0	1.9
List B*				
Trial 6	7.4	2.0	6.2	2.0
List A**				
Trial 7	12.6	2.2	10.7	3.0

Note. WAIS-R = Wechsler Adult Intelligence Scale—Revised.

* Maximum = 15.

* $p = .05$. ** $p = .005$.

Younger adults recalled more words than older adults, $F(1, 66) = 9.89, MS_e = 12.19, p < .003, \omega^2 = 0.12$. There was also a reliable practice effect across trials, $F(4, 264) = 219.68, MS_e = 1.41, p < .0001, \omega^2 = 0.76$, and a trend toward an interaction between age and practice ($p < .09$), which reflects the faster approach to asymptote by younger subjects. In addition, a t -test comparison of performance on the sixth trial—on which a new, unrelated list of words was presented for 1 trial—indicated that older adults performed more poorly than younger adults, $t(66) = 2.4, p < .02$. A comparison of the number of words from the first list that were forgotten after the interference list of Trial 6 indicated no age difference. Of course, differential learning over the first 5 trials makes interpretation of performance on the last 2 trials difficult. Overall, these scores suggest age differences in direct memory, with no clear indication of increased retroactive or proactive interference.

Relationship of Repetition Priming and Standardized Tests

Correlational analyses were also carried out between the standardized test scores and the results of the sentence-completion test. Two hypotheses were tested. First, it seemed possible that individual differences in repetition priming might be related to performance on related tests. Therefore, correlations were calculated between priming scores and each standardized test. However, none of these was statistically significant. The second hypothesis was that subjects who remembered relatively more disconfirmed words than target words should also perform more poorly on tests of speeded word retrieval, response interference, and direct memory. In other words, the tendency for older adults to focus more on the disconfirmed than target words may be related to performance on these tasks. To test this, a second set of correlations was calculated, using a score representing the relative amount of priming subjects demonstrated in the two conditions. This score was calculated for each subject by subtracting the priming score on target items from the priming score on disconfirmed items. A higher score on this variable indicates greater relative priming of disconfirmed as compared with target items.

For older adults, there was a significant negative correlation between the number of words generated on the CWAT and the tendency to learn more disconfirmed than target words ($r = -.42, p < .04$). Similarly on the Stroop color-word subtest, older subjects who responded more slowly showed greater relative priming of the disconfirmed words ($r = .41, p < .05$). The pattern on the RAVLT was identical: a significant negative correlation with greater relative priming of disconfirmed words ($r = -.43, p < .04$). In all three cases, poorer performance on the standardized tests was associated with relatively more repetition priming of disconfirmed words. In contrast, vocabulary level was uncorrelated with repetition priming.

For younger adults, none of these correlations even approached significance, except for marginal associations between the Stroop color-word time and the tendency to attend more to disconfirmed words ($r = .27, p < .08$).

Awareness, Repetition Priming, and Aging

Because a large proportion (54%) of younger adults and very few (13%) older adults became aware of the relationship be-

tween the study sentences and the sentence-completion test, it was important to determine whether this awareness was associated with different patterns of performance. Therefore, additional analyses were conducted with awareness included as a between-subjects variable. Only data from the younger subjects were included, because only 3 older adults reported such awareness.

This analysis of the sentence-completion test revealed no significant effects involving awareness ($F_s < 1$). However, aware subjects recalled more words on the RAVLT than unaware subjects, $F(1, 42) = 5.88$, $MS_e = 9.95$, $p < .02$, $\omega^2 = .10$. Thus, awareness is associated with better performance on a direct but not an indirect memory test. Unaware and aware subjects also did not differ in their vocabulary scores or performance on the CWAT or Stroop tests.

Discussion

The focus of this experiment was an examination of age differences in inhibitory mechanisms, as reflected in memory for target and disconfirmed words that comprised the endings of high-cloze sentence frames. The disconfirmed words were presumably generated as likely endings for high-cloze sentences that were missing their final words. These likely endings were disconfirmed (and so became irrelevant) when the to-be-remembered target endings were presented. The main prediction was that older adults would be relatively unable to suppress irrelevant information that was generated but no longer relevant (i.e., the disconfirmed endings). Both sentence endings should then be remembered. Conversely, younger adults should be able to efficiently suppress irrelevant thoughts (the disconfirmed words), and they should then show memory only for the targets. The data were consistent with this prediction: Older adults showed equivalent repetition priming of both types of stimuli; younger adults showed repetition priming of only the targets.

These findings offer support for the hypothesis that inhibitory mechanisms operate less efficiently in older adults. Assuming that all subjects generated the disconfirmed endings for the sentence frames, the older adults apparently had greater difficulty in discarding this information. One can speculate that both the target and disconfirmed words entered working memory at the time of encoding, but the relative inability of older adults to suppress the disconfirmed words resulted in further processing and subsequent retention of the latter. Thus, this pattern of results indicates a difference in the contents of the memories of younger and older adults.

Of course, it is possible that younger adults were more sensitive to task demands and, as such, may not have generated the predicted endings for the experimental sentences. After all, half the time these endings quickly became irrelevant, because of the presentation of unlikely endings. The adoption of a passive strategy by younger but not older participants could explain the absence of repetition priming for disconfirmed words in the former age group. To assess the validity of this alternative interpretation, data were collected with a new group of 24 younger adults. The experimental procedures were identical to those in the main experiment, with one key exception: During the presentation of study sentences, subjects were required to generate an ending aloud before the target word appeared on

the screen. Scores on the indirect memory test were then made conditional on the subjects' having generated the "correct" disconfirmed words. (Each subject produced an average of 1.5 "incorrect" generations out of 14.) The pattern of results was identical to that reported for the current experiment. Subjects showed greater repetition priming for targets (13.3% above baseline) than for disconfirmed words (3.3% above baseline), and the amount of priming for disconfirmed words did not differ from zero, $F(1, 23) = 6.65$, $p < .02$, $\omega^2 = 0.18$. Thus, the evidence from the main experiment, showing that only older adults remembered the disconfirmed items, is not tied to age differences in generation of high-cloze endings during sentence processing. Young subjects clearly generated the high-cloze endings when asked; yet there is no evidence of retention of these endings. Thus, age differences in priming must be attributed to factors that operate after items have come to mind. It is at this point that inhibitory mechanisms are important and age differences in suppression are believed to have occurred.

The data also suggest that the tendency for older adults to hold onto disconfirmed information resulted in less knowledge of the target stimuli. Consistent with other research (Chiarello & Hoyer, 1988; Light & Singh, 1987), the overall amount of repetition priming was equivalent for the two age groups, but for the older adults, this priming involved a combination of target and nontarget information. Although this may represent differences occurring during the acquisition of information, an alternative explanation cannot be ruled out: Age differences in retrieval processes might also account for this pattern of findings. For instance, the linking of the target with the disconfirmed information during the study task may have differentially reduced the retrievability of the target information for older adults due to heightened competition (Zacks, Radvansky, Hasher, & Gerard, 1990).

The major findings of memory for disconfirmed items by older but not younger adults are consistent with the attentional theory of Hasher and Zacks (1988). The data also offer evidence that failure to suppress irrelevant (in this case, disconfirmed) information will be associated with negative consequences for related aspects of cognitive functioning as well. For example, individuals with difficulty suppressing irrelevant thoughts are likely to show disruptions from actually presented irrelevant information (as occurs on Stroop color-word trials), to have word-finding problems (because of interference from other irrelevant ideas), and to have greater difficulty in a free-recall learning situation (in which disruptions due to irrelevant thoughts can occur at both study and testing). An examination of the individual patterns of correlations was consistent with this view. Older adults who learned relatively more of the disconfirmed than the target items showed greater disruption on Stroop color-word interference trials, reduced fluency on the CWAT, and poorer overall recall on the RAVLT. Obviously, these correlational findings cannot support strong conclusions, and further work is needed to ascertain whether these correlations are due to a generalized decline across functions or to the effect of reduced inhibition of irrelevant information on explicit memory and word retrieval processes. Nevertheless, the patterns of correlations suggest that inefficient inhibitory mechanisms may play a role in a range of cognitive functions.

The idea that aging produces a decrease in the ability to ig-

nore irrelevant information is of course not a new one. For example, increased interference for older adults on the Stroop test is a well-established finding (e.g., Comalli et al., 1962). In the context of a sentence priming task, older adults also show increased difficulty in switching attention from a sentence frame to an incongruous ending, a situation that requires the suppression of irrelevant information (Nebes, Boller, & Holland, 1986). Age differences in distractibility have also been found in visual search paradigms if the spatial location of the target is not known in advance (Farkas & Hoyer, 1980; Madden, 1983; Plude & Hoyer, 1985; Rabbitt, 1965). Even when there is no spatial uncertainty, age differences in interference appear if distractors are difficult to discriminate from targets (Farkas & Hoyer, 1980; Wright & Elias, 1979).

In spite of this literature and the results of the current study, some other research in the area of memory has suggested that older adults do not necessarily retain more irrelevant information than younger adults. In incidental learning paradigms, older adults have sometimes shown less accurate memory for task-irrelevant information than younger adults. For instance, there are age decrements in memory for the source of information (Cohen & Faulkner, 1989; Hashtroudi, Johnson, & Chrosniak, 1989; Rabinowitz, 1989), for irrelevant distractors (Kausler & Kleim, 1978), and for other contextual information (Kausler, 1982). We suggest that this pattern of findings may depend on two factors: (a) the relationship between the irrelevant and relevant material and (b) the type of memory test used.

With respect to the first factor, the relationship between the irrelevant and relevant information, we note that in the current experiment, the sentence frames established clear associations between the targets and disconfirmed words. In much of the previously published research, the incidentally presented material had little or no meaningful relationship with the target material. In addition, the instructions and the construction of the sentence frames in our study task led subjects to expect nontarget words and thus provided further situational support for the learning of the disconfirmed words (for a related finding with typical and atypical script actions, see Hess, 1985). It may well be that older adults are better able to ignore (or fail to process) nontarget information when it is either unrelated in meaning to the targets or irrelevant to the experimental context. Indeed, in a recent experiment using reading time as a measure, older adults were differentially slowed by the presence of distractors that were meaningfully related, as compared with unrelated, to a target passage (Connelly, Hasher, & Zacks, 1991). In contrast, young adults were equally slowed by distracting information with and without meaningful connection to the target text.

With respect to the second factor, the type of memory test, the present experiment used an indirect memory test as a window into changes in the availability of previously experienced stimuli. This procedure appears to have provided a very sensitive measure of subjects' encoding processes. The obtained age differences in repetition priming are interpreted as a reflection of greater processing of the nontarget information by older as compared with younger adults. Other types of memory assessments, involving intentional retrieval, may be less sensitive to this aspect of information processing or may be disrupted by

factors impacting at the time of test.

In conclusion, the present experiment used an indirect memory test to reveal age differences in the handling of information that is generated but no longer relevant. When—as here—that information is meaningfully connected to the task framework, older, but not younger, adults have difficulty suppressing it. There is some suggestion as well that among older adults, the failure to suppress thoughts that are no longer relevant is associated with deficiencies in ignoring visually presented information, in solving word-finding problems, and in acquiring new information. The ability to suppress activated thoughts may be a powerful determinant of cognitive functioning, and the inability to suppress such thoughts may prove to play a major role in the cognitive disabilities of older adults.

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